Application of ultrafast X-ray diffraction to the study of condensed matter

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Ultrafast melting is believed to arise from a strong modification of the inter-atomic forces due to laser induced promotion of a large fraction of the valence electrons to the conduction band. Following excitation of the electrons, the atoms find themselves far from the new equilibrium positions and immediately begin to move, gaining enough kinetic energy to produce sub-picosecond melting[1].
We used the technique of time-resolve X-ray diffraction with a plasma x-ray source produced from the interaction of a 10Hz, 120fs, 16mJ Ti:Sa laser beam focused on a silicium target[2]. The emitted 7.12Å Kα X-ray radiation is expected to last 100fs, which can give a clear mapping of the atomic motions during phase transition. The X-ray radiation is collected by a toroidal quartz crystal and focussed onto Indium Antimony (InSb) semiconductor samples. We used a second laser pulse from this laser system to excite the sample at fluences ranging from 200mJ/cm^2 to 5mJ/cm^2, which is well below the damage threshold of the semiconductor. The depth and the time scale of non-thermal process have been fully characterized[3]. We also conducted experiments on thin film of Cadmium Telluride (CdTe) deposited on GaAs. The time scale of the transition is found to be similar to the behaviour of bulk InSb for the high exciting fluences, even within the first layers of the crystal.

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2.Rischel, C. et al., "Femtosecond time-resolved X-ray diffraction from laser heated organic films," *Nature* **390**, 1997.
3.Rousse, A. et al., "Non-thermal melting in semiconductors mesured at femtosecond resolution," *Nature* **410**, 2001.